

NEUTRINO - ELEMENTARY PARTICLES OR PHANTOMS

V.P. Efrosinin

Institute for Nuclear Research, Russian Academy of Sciences,
pr. Shestidesyatiletia Oktyabrya 7a, Moscow, 117312 Russia

Abstract

The problem of statistical uncertainty of an estimation of parameters of neutrino oscillations with χ^2 -test is discussed.

In Ref. [1] CPT theorem check has been spent to models of two-neutrino mixing in which short-baseline at definition of parameters of mixing $\sin^2 2\theta$ and squared-mass $\delta m_\nu^2 = |m_2^2 - m_1^2|$, properly:

$$P_{\nu_e \rightarrow \nu_e} = 1 - \sin^2 2\theta_\nu \sin^2 \left(\frac{\delta m_\nu^2 L}{4E} \right), \quad (1)$$

where L - distance from the source to the detector.

If the CPT theorem is carried out a similar parity of (1) can be fair and for an $\bar{\nu}$:

$$P_{\bar{\nu}_e \rightarrow \bar{\nu}_e} = 1 - \sin^2 2\theta_{\bar{\nu}} \sin^2 \left(\frac{\delta m_{\bar{\nu}}^2 L}{4E} \right). \quad (2)$$

For calculation of parameters δm_ν^2 , $\sin^2 2\theta_\nu$ and $\delta m_{\bar{\nu}}^2$, $\sin^2 2\theta_{\bar{\nu}}$ the goodness-of-fit method was used [2]. Also asymmetries for mass and mixing are calculated:

$$\begin{aligned} A_{\delta m^2}^{CPT} &= \delta m_\nu^2 - \delta m_{\bar{\nu}}^2, \\ A_{\sin^2 2\theta}^{CPT} &= \sin^2 2\theta_\nu - \sin^2 2\theta_{\bar{\nu}}. \end{aligned} \quad (3)$$

The best-fit values of the asymmetries corresponding to χ_{min}^2 , are presented in [1]:

$$A_{\sin^2 2\theta}^{CPT} = 0.42, \quad A_{\delta m^2}^{CPT} = 0.37 eV^2. \quad (4)$$

Authors of [1] consider that there is indication of a CPT-violating asymmetry in experiments on a survival of the neutrino and the antineutrino from the contradiction of the data from radioactive sources and reactor sources.

In our article [3] arguments against conclusions have been stated article [1]. In particular the attention has been paid that the technique of [2] does not allow to estimate uncertainty of defined parametres. Which can be rather more than uncertainty of χ_{min}^2 definition [4].

In the present article we add arguments about it and we define in the order of size a dispersion of δm_ν^2 and δm_ν^2 .

First of all we notice from classification of neutrino oscillation experiments by size of the relation L/E sensitivity of δm^2 :

1. Experiments with short-baseline. In these experiments $L/E \leq 1eV^{-2}$, sensitivity $\delta m^2 \geq 0.1eV^2$. Experiments concern this type with radioactive sources and reactor experiments.

2. Experiments with long-baseline and atmospheric experiments. For them $L/E \leq 10^4eV^{-2}$, sensitivity $\delta m^2 \geq 10^{-4}eV^2$. Examples of such experiments are reactor experiment CHOOZ, accelerator experiment MINOS.

3. Experiments with very big flying base and solar experiments. The example is reactor experiment KamLand with $L \simeq 180km$, $E \simeq 3MeV$, thus $L/E \simeq 3 \cdot 10^5eV^{-2}$, and sensitivity $\delta m^2 \geq 3 \cdot 10^{-5}eV^2$. For solar neutrino experiments GALLEX, GNO, SAGE, $L \simeq 1.5 \cdot 10^8km$, $E \simeq 1MeV$, $L/E \sim 10^{12}eV^{-2}$, and sensitivity $\delta m^2 \geq 10^{-12}eV^2$.

Procedure of calculation of oscillations parametres is difficult. Nevertheless there is a question.

Whether the same physical combination of neutrino masses can change at increase in flying base? If can, then it any more that it is accepted to name masses. Then it is not so elementary particles, and certain phantoms.

In a formula (1) conclusion it is supposed that all neutrinos in a bunch possess the same fixed momentum with the big accuracy of δm^2 assuming definition. In experiments at long baseline the bunch is built in a direction and on momentum size. Character of a bunch becomes more suitable to the assumption of an applied formalism. From here and more precisely there is δm^2 calculation. That has no place at short baseline experiments.

In the S-matrix theory the final condition is considered removed enough from a reaction place. Then the right answer about δm^2 it is necessary to look at least in experiments with long-baseline. Further we consider that δm^2 in these experiments essentially is less, than in experiments with short-baseline and we assume normal distribution of δm^2 . Then with probability 68,3%, root from dispersion of δm^2 in experiments with short-baseline in the order of size will be equal to the parametre δm^2 .

Further we will use the date of the review [5] concerning δm_{min}^2 from experiments with short-baseline for the channel $\nu_\mu \rightarrow \nu_e$:

<i>channel</i>	$\delta m_{min}^2(eV^2)[Ref]$
$\nu_\mu \rightarrow \nu_e$	0.075[6]
$\nu_\mu \rightarrow \nu_e$	0.4[7]
$\nu_\mu \rightarrow \nu_e$	1.6[8, 9]
$\nu_\mu \rightarrow \nu_e$	0.4[10]

(5)

We calculate root-mean-square value of $\delta m_{\nu min}^2$ for four experiments of the channel $\nu_\mu \rightarrow \nu_e$. Also we receive value for uncertainty $\delta m_\nu^2 - \sigma_\nu = 0.42eV^2$. Value for uncertainty $\delta m_{\bar{\nu}}^2$ it is received from Ref. [11], where the interval for $\delta m_{\bar{\nu}}^2$ is $0.2 \leq \delta m_{\bar{\nu}}^2 \leq 2eV^2$. Then for uncertainty of $\delta m_{\bar{\nu}}^2$ - we receive value - $\sigma_{\bar{\nu}} = 0.2eV^2$. Uncertainty of asymmetry $A_{\delta m^2}^{CPT}(3)$ σ_A is equal

$$\sigma_A = \sqrt{0.42^2 + 0.2^2} = 0.46eV^2. \quad (6)$$

Taking into account the equations (4) there is in our approach no hint on CPT-violation from results of Ref. [1].

In summary we do a conclusion that neutrino oscillation experiments with short-baseline are not approaching at least for definition of CPT-violation.

References

- [1] C. Giunti, M. Laveder, arXiv: 1008.4750 [hep-ph].
- [2] M. Maltoni, T. Schwetz, arXiv: 0304176 [hep-ph].
- [3] V.P. Efrosinin, arXiv: 1101.3410 [hep-ph]
- [4] J.C. Collins, J. Pumplin, arXiv: 0105207, [hep-ph].
- [5] M.C. Gonzalez-Garcia, M. Maltoni, arXiv: 0704.1800v.2 [hep-ph].
- [6] L. Borodovsky et al. [E776 Collaboration], Phys. Rev. Lett. **68**, 274 (1992).
- [7] L.A. Ahrens et al. [E734 Collaboration], Phys. Rev. **36D**, 702 (1987).
- [8] A.Romosán et al. [CCFR/NuTev Collaboration], Phys. Rev. Lett. **78**, 2912 (1997).
- [9] S. Avvakumov et al. Phys. Rev. Lett. **89**, 011804 (2002).
- [10] P.Astier et al. [NOMAD Collaboration], Nucl. Phys. **611B**, 3 (2001).
- [11] C. Giunti, M. Laveder, arXiv: 1010.1395 [hep-ph].